

## PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY  
(Chapter II of the Patent Cooperation Treaty)

PCT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P06478PC00	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/SE2004/002018	International filing date (day/month/year) 23-12-2004	Priority date (day/month/year) 30-12-2003
International Patent Classification (IPC) or national classification and IPC See Supplemental Box		
Applicant Telefonaktiebolaget LM Ericsson (publ) et al		

- This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
- This REPORT consists of a total of 5 sheets, including this cover sheet.
- This report is also accompanied by ANNEXES, comprising:
  - ☒ (sent to the applicant and to the International Bureau) a total of 8 sheets, as follows:
    - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
    - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
  - ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) \_\_\_\_\_, containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

- This report contains indications relating to the following items:
 

<input checked="" type="checkbox"/>	Box No. I	Basis of the report
<input checked="" type="checkbox"/>	Box No. II	Priority
<input type="checkbox"/>	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
<input type="checkbox"/>	Box No. IV	Lack of unity of invention
<input checked="" type="checkbox"/>	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
<input type="checkbox"/>	Box No. VI	Certain documents cited
<input type="checkbox"/>	Box No. VII	Certain defects in the international application
<input type="checkbox"/>	Box No. VIII	Certain observations on the international application

Date of submission of the demand  28-10-2005	Date of completion of this report  27-12-2005
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**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**

International application No.

PCT/SE2004/002018

**Supplemental Box**

In case the space in any of the preceding boxes is not sufficient.

Continuation of: Cover sheet

**INTERNATIONAL PATENT CLASSIFICATION (IPC) :**

**H04L 25/52 (2006.01)**

**H04B 7/14 (2006.01)**

**H04Q 7/32 (2006.01)**

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/SE2004/002018

## Box No. I Basis of the report

## 1. With regard to the language, this report is based on:

- ☒ the international application in the language in which it was filed
- ☐ a translation of the international application into \_\_\_\_\_, which is the language of a translation furnished for the purposes of:
- ☐ international search (Rules 12.3(a) and 23.1(b))
- ☐ publication of the international application (Rule 12.4(a))
- ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the elements of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

- ☐ the international application as originally filed/furnished
- ☒ the description:
- pages 1 - 28 as originally filed/furnished
- pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
- pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
- ☒ the claims:
- pages \_\_\_\_\_ as originally filed/furnished
- pages\* \_\_\_\_\_ as amended (together with any statement) under Article 19
- pages\* 29 - 36 received by this Authority on 2005-10-28
- pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
- ☒ the drawings:
- pages \_\_\_\_\_ as originally filed/furnished
- pages\* 1 - 10 received by this Authority on 2005-02-23
- pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
- ☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages \_\_\_\_\_
- ☐ the claims, Nos. \_\_\_\_\_
- ☐ the drawings, sheets/figs \_\_\_\_\_
- ☐ the sequence listing (*specify*): \_\_\_\_\_
- ☐ any table(s) related to the sequence listing (*specify*): \_\_\_\_\_

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages \_\_\_\_\_
- ☐ the claims, Nos. \_\_\_\_\_
- ☐ the drawings, sheets/figs \_\_\_\_\_
- ☐ the sequence listing (*specify*): \_\_\_\_\_
- ☐ any table(s) related to the sequence listing (*specify*): \_\_\_\_\_

\* If item 4 applies, some or all of those sheets may be marked "superseded."

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/SE2004/002018

Box No. II      Priority

1. ☒ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:  

☒ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).  
☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:

**Box No. V** Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

## 1. Statement

Novelty (N)	Claims	<u>1-28</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-28</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-28</u>	YES
	Claims		NO

## 2. Citations and explanations (Rule 70.7)

## Documents cited in the International Search Report:

D1: "Coverage enhancement through two-hop relaying in cellular radio systems" by Sreng V. et al. 2002

D2: WO 2004107693 A1

D3: "Adaptive optimal transmit power allocation for two-hop non-regenerativ wireless relaying system" by Zhang, J. et al. May 2004

D4: "Oppurtunistic large arrays: cooperative transmission in wireless multihop ad-hoc networks to reach far distances" by Scaglione, A. et al. 2003

D5: "Distributed space-time-coded protocols for exploiting cooperative diversity in wireless networks" by Laneman, J.N et al. 2003

The cited documents represent the general state of the art.

The invention defined in claims 1-28 is not disclosed by any of these documents.

The cited prior art differ from the claimed invention in that the cited documents do not describe communication networks using cooperative relaying. Especially not according to the claims, where there are overlapping coverage and soft association to a plurality of relay stations and that there are feedbacks about communication quality from the mobile to the base station and then adapting the quality from the base station to the relay stations.

Therefore, the claimed invention is not obvious to a person skilled in the art.

Accordingly, the invention defined in claims 1-28 is novel and is considered to involve an inventive step. The invention is industrially applicable.

## CLAIMS

5 1. A method of performing communication in a two-hop  
wireless communication network, wherein a base station  
(410), at least one mobile station (420) and a plurality of  
10 relay stations (415; 415:6-415:9, Fig 4) are engaged in, or  
in the process of establishing, a communication session,  
and wherein the relay stations (415) forward signals from  
the based station (410) to the at least one mobile station  
(420), said plurality of relay stations (415:6-415:9, Fig  
4) having at least partially overlapping coverage,  
c h a r a c t e r i z e d in that the method comprises the  
15 step of:

- establishing (805) by said at least one mobile station  
(420) a soft association to said plurality of relay  
stations (415) by internally selecting a set of relay  
channels from said number of relay stations (415:6-415:9),  
20 said set of relay channels associated to the relay stations  
(415) being candidates for use in the communication  
session,

- feeding back (835, Fig 8) from the at least one mobile  
station (420), during the communication session, information

25 on the communication quality to the base station (410); and  
- adapting (810) in the base station (410) the transmission  
to at least one of the relay stations (415) which the  
mobile station (420) has soft association with, in response  
to the communication quality feedback from the at least one  
30 mobile station.

2. The method according to claim 1, for a specific mobile  
station, wherein the step of selecting (805) comprises the  
substep of:

- the mobile station 420 measures (1405) the relay channel quality of said plurality of the relay stations of the relay cluster (440).

5        3. The method according to claim 2, wherein in the step of measuring (1405) the mobile station measures on pilots sent by the at least one relay station (415).

10       4. The method according to claim 2, wherein in the step of measuring (1405) the mobile station measures on pilots sent by the base station (410) and forwarded by the at least one relay station (415).

15       5. The method according to claim 2 to 4, wherein the step of selecting (805) comprises the further substep of:  
- the mobile station (420) determines (1410) bandwidth requirements based on a current application executed in the mobile station or anticipated future applications; and said selection is based both on the relay channel quality measurements and the bandwidth requirements.

20       6. The method according to any of claims 1 to 5, wherein the step of selecting (805) is repeated during the communication session in order to adapt to changing conditions in the radio environment.

25       7. The method according to any of claims 1 to 6, wherein the method comprises the further steps of:

- at least one mobile station (420), during the communication session, feeding back (835) information on the communication quality to the base station (410); and  
30       - the base station (410) further adapting (810) the transmission to at least one of the relay stations (415)

which the mobile station (420) has soft association with, in response to the communication quality feedback from the at least one mobile station.

5 8. The method according to claim 1 or 7, wherein the step of the base station adapting (810) the transmission comprises the further substeps, to be performed by the base station (410), of:

10 - identifying (810:1) from the feedback conflicting demands from at least two mobile stations (420) regarding the usage of at least one relay station (415), said two mobile stations (420) having soft association to the same as least one relay station (415);

- initiating an optimization process (810:2) for resolving the conflicting demands;

15 - adapting (810:2) the transmission at least to the relay stations to which the two mobile stations have soft association, taking into account the result of the optimization process (810:3).

20 9. The method according to claims 7 or 8, wherein the step of feedbacking (805) comprises that the mobile station feeds back raw channel state information to the base station (410).

25 10. The method according to claims 7 or 8, wherein the step of feedbacking (805) comprises that the mobile station feeds back processed channel state information to the base station (410).

30 11. The method according to claim 10, wherein the step of feedbacking (805) comprises that the mobile station feeds back any of, or any combination of, the following parameters to the base station (410): link mode, coding scheme, modulation scheme and antenna transmit weights.



12. The method according to any of claims 1 to 11, wherein the method comprises MIMO based communication between the transmitter (520) and the relay stations (415).

5 13. The method according to claim 12, wherein the transmitter of a base station (410) sends a vector  $\mathbf{T}$  over channel matrix  $\mathbf{H}$ , where each row of the matrix  $\mathbf{H}$  corresponds to one or more relay stations (415) using the same forwarding relay channel, and the matrix  $\mathbf{H}$  comprises  
10 as many rows as there are relay forwarding channels.

14. The method according to claim 12, wherein the transmitter of a base station (410) sends a vector  $\mathbf{T}$  over channel matrix  $\mathbf{H}$ , where each row of the matrix  $\mathbf{H}$  corresponds to one or more relay stations (415) using the  
15 same forwarding relay channel, and there are at least two forwarding relay channels.

15. The method according to claim 12, wherein the transmitter of the base station (410) uses singular value decomposition (SVD) of the channel matrix  $\mathbf{H}$  and applies a  
20 unitary weight matrix ( $\mathbf{U}$ ) to the outputted signal to facilitate a diagonalization with the use of the Hermitian of a unitary weight matrix ( $\mathbf{V}$ ).

16. The method according to claim 12, wherein singular value decomposition (SVD) is used and the method comprises  
25 the steps of:

- the transmitter of a base station (410) sending a vector  $\mathbf{T}$  over channel matrix  $\mathbf{H}$ , where each row corresponds to one or more relay stations (415) using the same relay channel and there are as many relay channels as there are rows in  
30 the channel matrix, and applying a unitary weight matrix ( $\mathbf{U}$ ) to the outputted signal;

- the receiver performing a diagonalization by multiplying the received signal with the Hermitian of a unitary weight matrix  $V$ , whereby the receiver is able to directly receive a number of parallel substantially self-interference free MIMO subchannels.

17. The method according to any of claims 1 to 16, wherein the method of performing communication is preceded by a process of organizing relay stations (415) so that the channels of at least two neighbouring relay stations (415) are essentially orthogonal and the coverage of the at least two neighbouring relay stations are arranged to have substantial overlap.

18. The method according to claim 17, wherein the overlap between the two neighbouring relay stations is above 10% of the coverage area of the relay station exhibiting the smallest coverage area.

19. A system adapted for communication in a two-hop wireless communication network, wherein the network comprises at least a base station (410), at least one mobile station (420) and a plurality of relay stations (415), wherein the relay stations (415) are adapted to forwarding signals from the base station (410) to the mobile station (420), -at least a portion of the plurality of relay stations (415) are organized so that at least two neighbouring relay stations (415) have substantially overlapping coverage, and the channels of the relay stations (415) with overlapping coverage are essentially orthogonal; c h a r a c t e r i s e d i n t h a t

- at least one mobile station (420:1) is arranged to select a set of relay stations (420) from the relay stations (415) with at least partially overlapping

coverage, thereby establishing soft association to a plurality of relay stations (415) which are candidates to use in communication between the base station (405) and the mobile station (420), and

5 - logical feedbacks (550) between the mobile stations (420) and the base station (410), wherein the logical feedbacks carries information usable by the base station (410) to adapt transmit parameters for the transmission to the relay stations (415).

10 20. The system according to claim 19, wherein a plurality of mobile stations (420) are arranged to select individual sets of relay stations from the portion of relay stations (415) with at least partially overlapping coverage.

15 21. The system according to claim 19 or 20, further characterized in that the forwarding performed at the relay stations (415) during a communication session is not essentially dependent on control signalling directly  
20 between the mobile stations (420) and the relay stations (415)

25 22. The system according to claim 19, wherein in the logical feedback carries information on the set of soft associated relay stations (415) for each mobile station (420).

30 23. A receiver (520) adapted for use in a two-hop wireless communication network, wherein the network comprises a transmitter (510), a receiver (520) and at least one relay station (415), wherein the relay station (315) is adapted to forwarding signals from the transmitter (510) to the receiver (520) characterised in that the receiver (520) is provided with:

- selecting means (524) adapted for selecting a set of relay stations (425) from a plurality of relay stations (415) with substantially overlapping coverage, said selecting means arranged to base the selection on relay channel quality;

- feedbacking means (523) adapted for feedbacking the information on selected relays to the transmitter (510).

24. The receiver according to claim 23, wherein the feedbacking means comprises means for feeding back raw channel state information for each relay channel to the transmitter (510).

25. The receiver according to claim 23, wherein the feedbacking means comprises means for feeding back processed channel state information for each relay channel to the transmitter (510).

26. A base station (410) adapted for use in a two-hop wireless communication network, wherein the network comprises a base station (410), at least one mobile station (420) and at least one relay station (415), wherein the relay station (315) is adapted to forwarding signals from the base station (410) to the mobile station (420), the base station (420) comprising means for receiving feedback from the mobile station on the transmission to the mobile station, c h a r a c t e r i z e d in that the base station (420) is provided with:

-optimization means (515) adapted for identifying conflicting demands from at least two mobile stations (420) regarding the usage of at least one relay station (415), said two mobile stations (420) having soft association to the same as least one relay station (415), and adapted for

performing an optimization process for resolving the conflicting demands;

- transmission parameter adapting means (514) adapted for determining transmission parameters for the transmission at least to the relay stations to which the two mobile stations have soft association, taking into account the result of the optimization process.

27. The base station (410) according to claim 26, wherein the transmitter of the base station (410) is adapted to perform MIMO based communication and sending a vector  $T$  over channel matrix  $H$ , where each row of the matrix  $H$  corresponds to one or more relay stations (415) using the same relay channel and there are as many relay channels as there are rows in the channel matrix.

28. The base station (410) according to claim 27, wherein the transmitter of the base station (410) is adapted for using singular value decomposition (SVD) and apply a unitary weight matrix ( $U$ ) to the outputted signal to facilitate a diagonalization with the use of a Hermitian of a unitary weight matrix ( $V$ ).